A Molluscan Paleocommunity:

A Speculative Model for an East-West

Trending, Shallow-Marine Miocene Shelf, Navidad, Chile

A thesis presented in partial fulfillment of the requirement for the degree Bachelor of Science in Geology.

by

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Abstract

A subtropical Miocene marine molluscan community is developed from the fossil shells collected by Dr. William J. Zinsmeister. The shells were collected from locations along the coastal and inland areas surrounding Navidad, Chile.

The exposed sediments of Navidad are early to middle Miocene in age. Cecioni (1978, 1980) records, from well logs and observations, that sediments had accumulated since the Cretaceous period. Their deposition closely follows the major Andean uplift at the close of the Cretaceous period.

The bathymetric and sedimentary trends that seem apparent, when the molluscan paleocommunity is developed, point to Navidad as marking an east-west trending, shallow-marine shelf and offshore island complex that turns southward to the east of Navidad.

Acknowledgments

Where would this project be without Dr. Bill Zinsmeister? Thanks have to be given to him for taking interest in this beginner and providing me with the fossil collection from Navidad, Chile. He showed the confidence in me that provided a comfortable place to learn and work. He pointed the way and I went. To Tom DeVries and Carlos Macellari, they both gave freely of their time and resources, never a discouraging word. Whenever I needed help with my direction or needed encouragement they were there. To Brian Huber, who shared with me the frustration of an inadequate cluster analysis program.

Thanks to everyone here whose opinions I regard so highly.

Trixie, your acknowledgment deserves a separate page.

D.F.G.

Table of Contents

List of Tables

List of Figures

Geography of the Fossil Molluscan Assemblage Locations

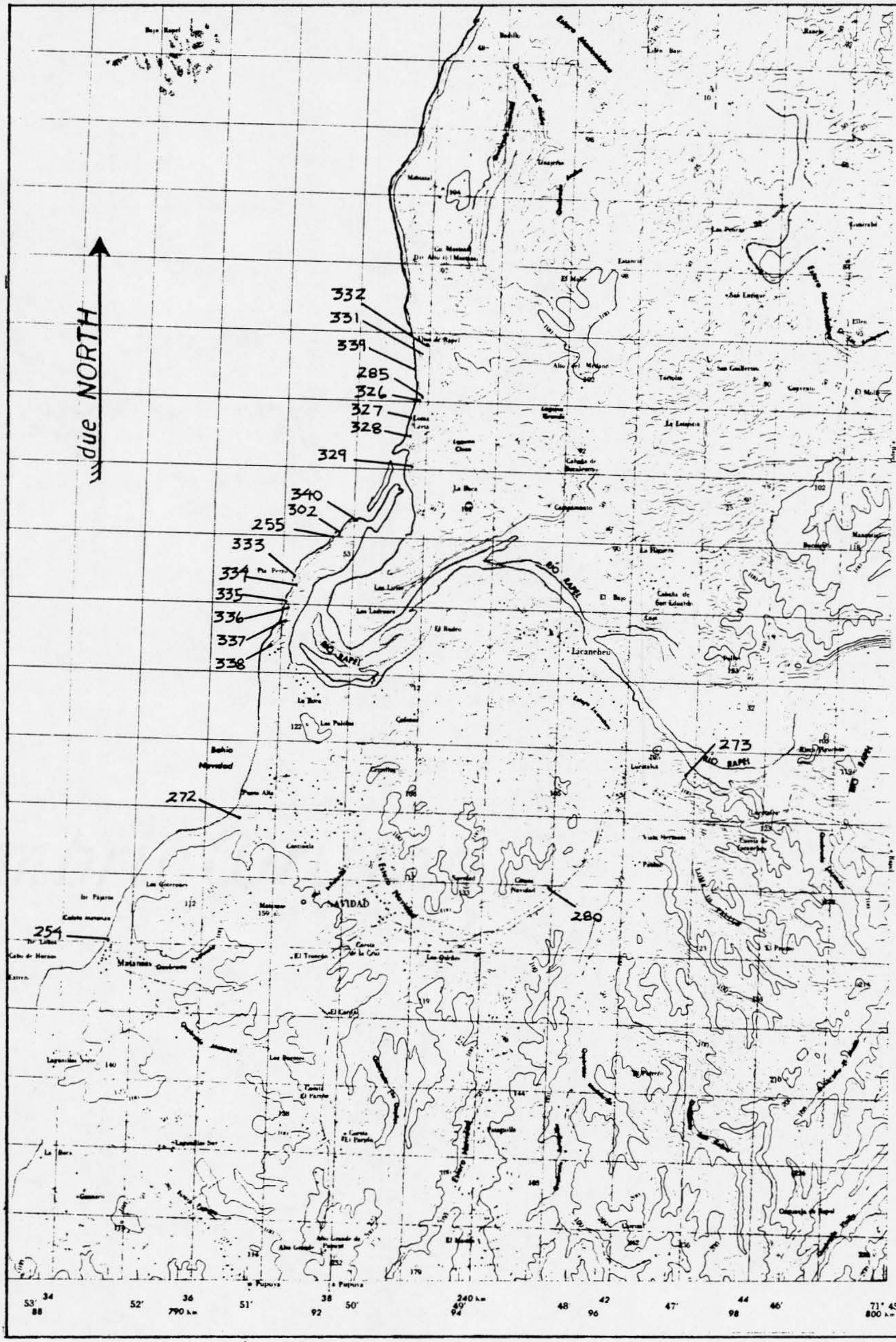
The proximity of Navidad, Chile, and the fossil assemblage locations are shown on the map in Figure 1. The latitude and longitude of each location is listed from north to south in Appendix I.

The assemblage locations are grouped into two (2) separate geographic regions. Locations 254 through 340 constitute the Southern assemblage group and locations 329 through 332 represent the Northern assemblage group. In general the Rio Rapel can be used to separate the two regions.

There are two (2) inland locations (273 and 280). They are both south of the Rio Rapel, but will be considered as part of the Northern fossil assemblage. This is based on their similarity to the Northern fossil assemblage localities.

The mollusks collected have been transported. The apparent degree of faunal mixing based on the differences in bathymetric preferences of the molluscan genera are the criteria used to separate the two regions (Table A).

Fig. 1 - Fossil location map, Navidad, Chile.



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52'
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51'
92
50'
240 km
49'
94
48
96
47'
98
46'
71° 45'
800 km

Fig.1

Table A.- The genera are grouped into either of three zones:

ZONE I - Intertidal to offshore just below low tide level.

ZONE II- Offshore to 75 meters.

ZONE III - 75 meters to deep.

The locations are listed from south to north to inland and grouped into their respective assemblages:

Southern assemblage- Deeper water assemblage.

Northern assemblage- Shallower water assemblage.

The genera's ecology is listed in terms of three ecological preferences:

1) Temperature preference, 2) Substrate preference, and 3) Feeding preference.

The data in the preference table is not complete. It should only be used as a guide in developing the sedimentary environment.

TABLE A.

MAIN ASSEMBLAGE TABLE

Zone	Genus	southern assemblage											northern assemblage										genera ecology: temp.		substrate					feeding	
		254	272	338	337	336	335	334	333	255	302	340	329	328	327	326	285	339	331	332	280	273	cold	warm	rocks	sand	mud	sandy mud	w/ debris	carnivore	other
ZONE I	1. Amiantis													•												•		•			•
	2. Bulla	•	•			•			•					•					•					•		•				•	
	3. Cardium														•		•						•	•		•	•	•			•
	4. Cassis		•					•	•					•		•	•		•	•				•		•				•	
	5. Conus	•																						•	•	•			•	•	
	6. Cypraea	•																						•	•				•		
	7. Diodora								•																•						•
	8. Kelletia							•																	•	•					
	9. Margarites	•																								•					•
	10. Mya		•																									•			•
	11. Mytilus	•		•	•		•		•										•				•	•	•						•
	12. Oliva	•				•	•		•	•		•		•		•	•		•	•	•					•				•	
	13. Ostrea		•						•					•						•					•	•		•			•
	14. Trochita	•																							•						
ZONE II	1. Arca	X																									X	X			X
	2. Calliostoma	X							X	X																X			X		X
	3. Cancellaria	X	X						X	X								X				X		X						X	
	4. Clavus								X	X										X			X	X		X	X		X	X	
	5. Dentalium	X	X					X	X	X	X		X	X					X	X			X	X		X					X
	6. Distorsio		X			X		X		X							X	X		X		X		X		X			X		
	7. Ficus					X							X			X								X		X				X	
	8. Glycymeris	X							X	X		X												X							
	9. Lucina	X						X																		X		X			X
	10. Neverita	X	X				X			X			X	X	X				X							X					X
	11. Raeta																				X									X	
	12. Tellina		X																							X	X	X			X
	13. Terebra	X	X		X				X	X							X	X		X				X		X				X	
	14. Vermetus	X																													X
ZONE III	1. Acteon	*	*			*																				*					
	2. Drepanocheilus		*									*														*	*				
	3. Limopsis		*																				*								*
	4. Voluta	*	*				*	*		*		*											*	*							
	5. Microglyphis	*	*																												
	6. Miltha	*	*																							*					*
	7. Neilo	*	*																												*
	8. Nucula										*												*			*					*
	9. Solariella	*																								*					
	10. Turricula	*	*				*	*	*	*	*												*	*		*	*	*		*	
	11. Xenophora											*											*	*		*					
	12. Yoldiella		*																									*			*

Introduction

The deposition of the Cretaceous and Miocene sediments at Navidad follows closely the uplift of the entire Andean orogenic belt during the late Cretaceous period. To the north are Cretaceous igneous intrusives (including some Paleozoic and Precambrian granites). To the south are chiefly Paleozoic metamorphic rocks with some Mesaz~~ia~~oic and Cretaceous intrusives included. It is these rocks that are the source rocks for the sediments at Navidad.

This report describes a subtropical Miocene molluscan community at Navidad. Dr. William J. Zinsmeister, of The Institute of Polar Studies at The Ohio State University, has put together a collection of Miocene mollusk shells from the coastal and inland areas surrounding Navidad.

Three fossil assemblages have been identified that typify a subtropical open marine paleocommunity consisting of intertidal, offshore shelf, and deeper-water zones. A model describing a west-east trending shoreline to the north of Navidad turning to the south inland, east of Navidad, is the result of a qualitative analysis of the bathymetric trends, as well as the directional trends of the transported sediments.

Navidad, Chile has been little studied since Darwin last visited the area in 1846, during the voyage of the H.M.S. Beagle. Other researchers, Daniel Frassinetti and Vladimir Cavacevich, Juan Tavera, and Geovanni Cecioni all have published papers on the Navidad area. Cecioni (1978, 1980) is the only author published in English. He describes a

NNW trending embayment open to the Pacific Ocean. Cecioni's work is a composite of his student's work over the years. There is merit to the idea of an embayment but there is also some skepticism as to its validity as a final solution. This area cannot be adequately described without the hidden trends evident in the fossil record (both macrofossil and microfossil records).

Most of the literature concerning Navidad is written in Spanish or German. It is obvious that a much broader base of information must be gathered before any firm conclusions can be discussed. This report does not attempt to make any firm interpretations. It is meant to put forth a reasonable interpretation based on the information at hand.

The Fossil Assemblages

The table listing the genera versus the locations (Table A) is set up to show the bathymetric and compositional relationships between each location. It is also set up to support the separation of the northern and southern fossil assemblages.

Many of the identified genera display a relatively large degree of bathymetric variability among the individual species of any one genus. Therefore, placement of the genera into bathymetric zones, as opposed to assigning specific depths, is the only acceptable method when working on the generic level. Because of the bathymetric variability, the genera that exhibit a relatively narrow margin of variability must be identified. These genera will be used to evaluate any bathymetric trends that are apparent in the Navidad area.

The genera are placed into any one of three bathymetric zones. They are: I) intertidal to offshore, just below the low tide level; II) offshore to about 75 meters; and III) 75 meters to deep.[1]

The fossil assemblages that typify these bathymetric zones are listed on the following page.

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[1] There are three (3) more groups listed in the Appendix but not considered because of either an extremely large degree of bathymetric variability, insufficient bathymetric data, or unsatisfactory classification information.

Zone I

- Intertidal to offshore -
just below the low tide level.

1. Amiantis sp.
2. Bulla brevicula Philippi.
3. Cardium sp.
4. Cassis tuberculifera Hupe.
5. Conus medinae Philippi.
6. Cypraea sp.
7. Diodora sp.
8. Kelletia sp.
9. Margarites sp.
10. Mya sp.
11. Mytilus volkmanni Philippi.
12. Oliva dimidiata Sowerby.
13. Ostrea bourgeoisi Philippi.
14. Ostrea alvurezi Philippi.
15. Trochita sp.

Zone II

- Offsore to 75 meters -

1. Arca sp.
2. Calliostoma unio Philippi.
3. Calliostoma nodifera? n. sp.
4. Cancellaria medinae Philippi.
5. Cancellaria sp.
6. Clavus sp.
7. Dentalium magus Philippi.
8. Dentalium sp.
9. Distorsio decussata ringens (Philippi).
10. Ficus sp.
11. Glycymeris covacevichi? n. sp.
12. Glycymeris sp.
13. Lucina sp.
14. Neverita sp.
15. Raeta sp.
16. Tellina sp.
17. Terebra undulifera Sowerby.
18. Terebra costellata Sowerby.
19. Vermetus sp.

Zone III

- 75 meters to deep -

1. Acteon chilensis Phillipi.
2. Drepanocheilus sp.
3. Limopsis sp.
4. Voluta sp.
5. Microglyphis sp.
6. Miltha (Mantanziella) vidali (Phillippi).
7. Neilo volckmanni (Phillippi).
8. Nucula sp.
9. Solariella poeppigii (Philippi).
10. Turricula sp.
11. Xenophora sp.
12. Yoldiella sp.

(The list of genera occurring at each location is located in Appendix 2. The list of genera not used in this bathymetric scheme are listed in Appendix 3.)

The Northern Fossil Assemblage

The northern assemblage is made up of locations 329 through 332 and the inland locations 280 and 273. It is a mixture of Zone I and Zone II faunas. The constitutent genera are:

Zone I	Zone II
1. Amiantis sp.	1. Cancellaria sp.
2. Bulla	2. Clavus sp.
3. Cardium sp.	3. Dentalium sp.
4. Cassis	4. Distorsio
5. Mytilus	5. Ficus sp.
6. Oliva	6. Neverita sp.
7. Ostrea	7. Raeta sp.
	8. Terebra

The general lack of confirmed deep water genera is the reason that the Northern assemblage is set apart from the Southern assemblage and the inland (Eastern) locations are considered as part of the Northern assemblage.

The Southern Fossil Assemblage

The Southern assemblage contains a mixture of molluscan genera that cover the spectrum of bathymetric zones, Zones I, II and III. The genera included in the Southern assemblage (locations 259 through 341) are:

Zone I	Zone II	Zone III
1. Bulla	1. Arca sp.	1. Acteon
2. Cassis	2. Calliostoma	2. Drepanocheilus
3. Conus	3. Cancellaria	3. Limopsis
4. Cyprea sp.	4. Clavus sp.	4. Voluta
5. Diodora sp.	5. Dentalium	5. Microglyphis
6. Kelletia sp.	6. Distorsio	6. Miltha
7. Margarites sp.	7. Ficus sp.	7. Neilo
8. Mya sp.	8. Glycymeris	8. Nucula
9. Mytilus	9. Lucina sp.	9. Solariella
10. Oliva	10. Neverita sp.	10. Turricula
11. Ostrea	11. Tellina sp.	11. Xenophora
12. Trochita sp.	12. Terebra	12. Yoldiella
	13. Vermetus sp.	

The Southern fossil assemblage, especially locations 254 and 333, contain a majority of the same fossil genera found among the Northern fossil assemblage locations. This implies that the source area of the Zone I and Zone II components are to the north and to the east.

Assemblage Discussion

The major trend that can be seen in the faunal Table (Table A), is that of an abrupt, sustained halt to deep-water mixing north of location 340, at the mouth of the Rio Rapel. It is this linear occurrence that separates the Southern assemblage (the deep-water assemblage) from the Northern assemblage (the shallow-water assemblage, Figure 2). This trend stands out when the locations are listed in order up the coast, from south to north.[1]

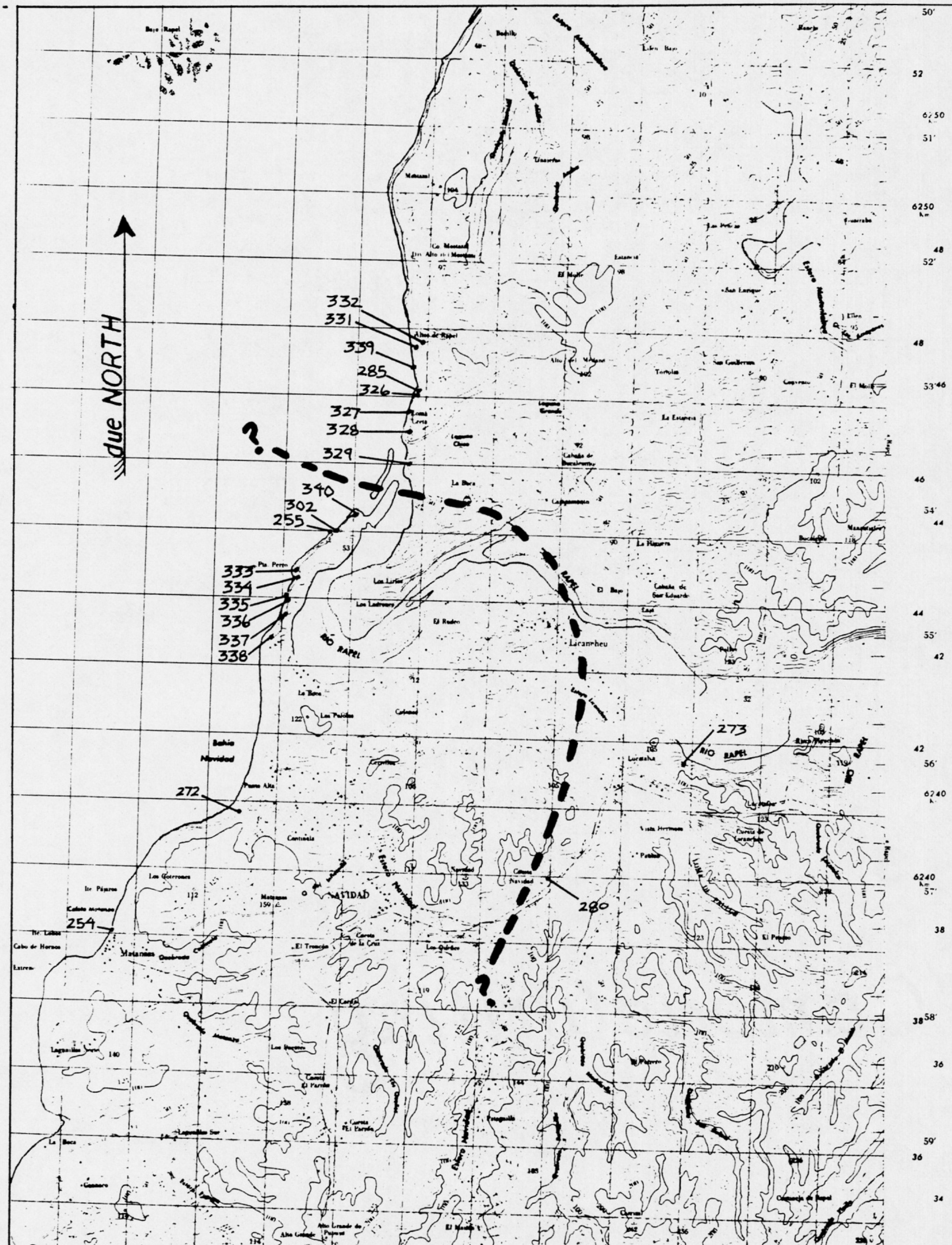
Secondary to the major bathymetric trend, seen when looking at the overall mixing scheme, are irregularities of faunal composition between individual localities, within the larger (Northern and Southern) assemblages.

Within the Southern assemblage, locations 338 and 337 do not contain a large number of collected specimens. This may be because these locations mark the area of a topographic high around which there was faunal stratification. Subsequent transport of the genera into the surrounding deeper waters can have left the area devoid of fossil material.

This same idea may be put forth for the localities that make up the Northern assemblage. It is evident that the Southern assemblage contains a major proportion of the Zone I and Zone II genera that occur in the Navidad area. This is due to the mass movement of materials down the shelf into deeper-water environments. But based on the relative abundance of Zone I versus Zone II generic components of the Northern assemblage, how might the irregular trends of the relatively shallower and deeper faunal compositions be explained. Again it is possible that an irregular bottom topography was present in the shallower environment of the Northern assemblage. The faunal stratification in this type of environment

[1] The occurrence of _Clavus_ sp. in the Northern assemblage at Location 332 leads me to believe that this is a shallow-water Turrid species. It is the same species found at localities 333 and 255 of the Southern assemblage.

Fig. 2- The line of seperation between the Southern and Northern assemblages, delineating the shoreline trend.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?
RIO RAPEL
Bahia Navidad
Licancheu
Altos de Rapel
Pta. Perro
La Boca
El Rodeo
Los Ladrones
Los Lirios
NAVIDAD
Matanzas
6250 km
6240 km
790 km
800 km
240 km
71° 45'
34° 00'

Fig. 2

would, upon transport, create an irregular mixing of genera, dependent on the degree of the relative topographic highs and lows throughout the area under consideration.

The Marine Ecology

The Marine Climate

A table listing the ecological preference of each genus is placed parallel to the assemblage table (Table A). This way the thermal and sedimentary preference of each genus can be correlated to each assemblage. Three (3) categories of ecology are presented: 1) thermal preference, 2) substrate preference; 3) feeding preference.

The faunal preferences represent a general statement of the shallow to deep water environments existing prior to or during the events that caused the mixing of the Miocene mollusks. The presence of genera unique to warm, shallow marine environments indicate that a subtropical to tropical marine climate prevailed at the time of deposition.

A cooler marine climate can be synonymous with a deep-water environment or possibly a high latitude region (Zinsmeister, pers. comm.). It is not surprising that most of the genera that fall into Zone III, the deep water genera, are listed as predominantly cold water genera or have adapted to both warm and cold marine climates.

The West Antarctic Ice Sheet

Consideration has been given to the phenomena of the West Antarctic Ice Sheet formation (Zinsmeister, 1978) as a possible cause for the cold water genera's presence with the subtropical mollusks. The formation of the West Antarctic Ice Sheet in the late Miocene closed off the

Shackleton Seaway. This deflected the cold polar waters of the West Wind Drift to the north along the west coast of Chile and through the Drake Passage. As a result, the cooling of the Humbolt current created a relatively colder marine climate and subsequently a like change in the faunal composition. This possibility has been put aside, however, because of the lack of reworked material and inadequate stratigraphic correlation in the Navidad area.

The Substrate Preference

Table A gives an account of the substrate preference of each genus within their respective bathymetric zone and assemblage position. The substrate pattern is extremely consistent when it is correlated to the bathymetric data.

Zone I - Intertidal to offshore, just below the low tide level is a substrate dominated by rocks and sand with possible localized mud flats.

Zone II - Offshore to 75 meters consists of a fine to medium-grained sandy substrate.

Zone III - 75 meters to deep, also shows a major homogeneous trend in the preference of the constituent genera. It consists of a sand and silt substrate.

The rather homogeneous sediment trends are reflected in the general coastal stratigraphic column of this area. The fossils come from within the fine-grained sandstone and turbidity horizons (Figure 3).

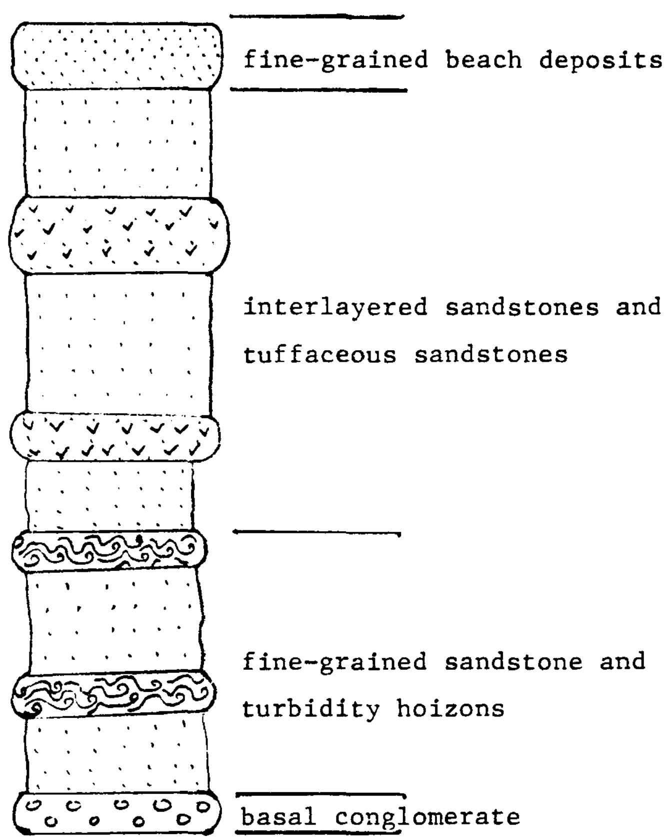

Fig. 3

A general coastal stratigraphic column, Navidad, Chile.

The Feeding Preferences

By listing the feeding preference of the individual genera (Table A), an indication of community diversity is established. A look at the predator to prey ratio on the whole indicates very nearly a one to one (1:1) ratio (~ .73:1, Appendix 4). The ratio indicates that this was an active, balanced marine community. The presence of a diverse fauna such as this implies a relative state of sedimentary and environmental stability had existed.

Environmental Discussion

The composite of the bathymetric and ecologic trends forms a general picture of the Navidad area. It suggests a well developed subtropical to tropical shallow marine environment and shoreline, to the north and to the east. Likewise, a deeper marine environment to the southwest. The overall environment is composed almost entirely of finer-grained sediments, sands and silts becoming rockier shoreward with possible local intertidal mudflats.

The irregularities exhibited by the plotted data on the faunal table suggests that an irregular bottom topography existed. Most likely the shallower environment, represented by the Northern assemblage, contained several islands that caused local faunal stratification.

Fossil Transport

In general the Rio Rapel is the dividing line between two fossil assemblages (the Northern assemblage and the Southern assemblage) separated by a molluscan faunal composition difference. The location assemblages are made up almost entirely of transported material. Transport means possible slumping of some sort.

It has been suggested that the transport is a result of turbidity currents (Zinsmeister, pers. comm.). Not only does the extensive mixing of the fossil material mimic the process of slumping or turbidity flows, in direction to the west and to the south, but some of the fossil material was contained within a sediment matrix indicative of turbidites (Krissek, pers. comm.).

> The sediments were made up of loosely consolidated fine-grained tan to gray sandstone with irregular bits of coal debris scattered throughout the sediment matrix.

The condition of the fossil mollusk shells must have some significance when considering the depositional environment. The fossils are well mixed and in excellent condition. The lack of abrasion and the wholeness of the shells requires that there be maximum mixing of the molluscan fauna with a minimum amount of reworking. Transport in a rapid fluid flow over a relatively short distance may account for this phenomena.

The turbidites do not exhibit a large degree of graded bedding. This is because the flow matrix is, to a large extent, made up of the same grade material.

Transport Trends

According to Dr. William J. Zinsmeister (pers. comm.) evidence for turbidity currents decreases inland, to the east. This holds with the bathymetric trends discussed earlier. That is deepening to the west and to the south from the northern assemblage locations.

A slide taken by Dr. William J. Zinsmeister shows a pocket of *Turritella* sp. gastropods all oriented in a north-south direction (Figure 4). This corresponds nicely to the deepening bathymetric trend that runs from north to south. Whether or not one pocket of these gastropods, by itself, is enough to infer regional trend is academic. But in conjunction with the other available data it is an important piece of information.

Cecioni (1978) has described the coastal stratigraphy in terms of four members of the Miocene Punta Perro - La Era Formation. The coastal section was described at Punta Perro (Figure 1) and consists of Member I (31.4 meters in thickness) and 8.5 meters of Member II (Figure 5). The rest of the section is described at La Era to the southeast.

The general lithological composition of Cecioni's stratigraphic section is very similar to the general coastal stratigraphic section presented earlier (Figure 3). More interesting than the lithological details of Cecioni's work, however, is his documentation of the southerly and westerly thinning of the various sedimentary beds. This trend

Fig. 4

North - south oriented Turritella sp. gastropods.

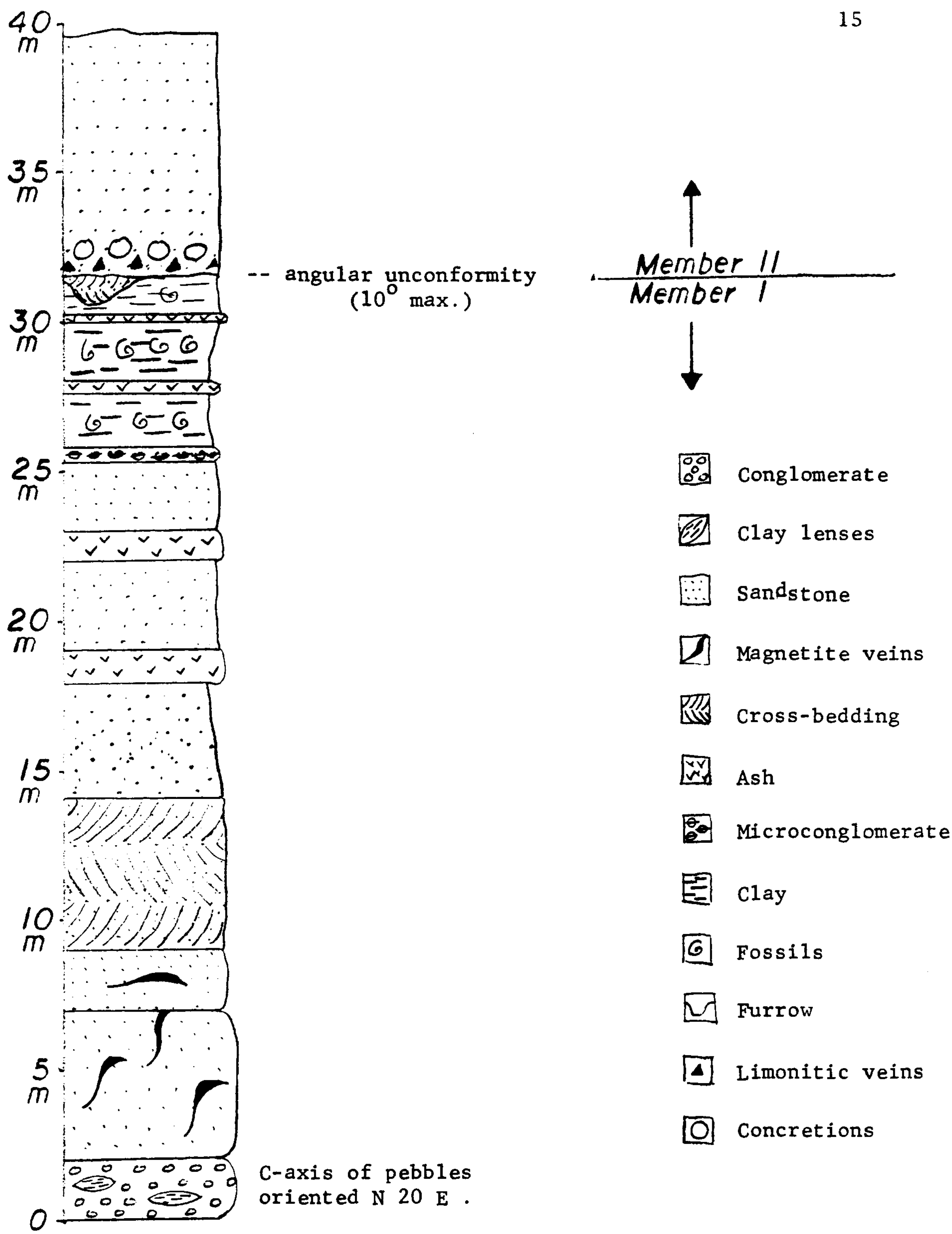

Fig. 5

Cecioni's coastal stratigraphic column, Punta Perro.
Adapted from Cecioni, 1978.

infers that the source area of the sediments lies to the north and to the east, most probably the Cretaceous granites and metamorphics that surround the Cretaceous through Tertiary sedimentary deposits of the Navidad area.

Cause of Transport

The turbidity currents had to be caused by something. Three possibilities have been considered: 1) that oversteepening along the shelf ridge due to sediment accumulation, followed by the rapid sedimentation of volcanic tuffs, caused the turbidity currents (Zinsmeister, pers. comm.). The slump of the oversteepened sediments may have been triggered simply by seismic activity due to the volcanism that created the overlying tuffaceous material. 2) Contrary to oversteepening of the sediments at the shelf margin, seismic activity can be strong enough to simply cause non-oversteepened, but liquid laden, sediments to move in the down slope direction. This may explain the irregular mixing patterns brought forth in the discussion on the assemblages. 3) Along the lines of seismic activity linked to volcanism, the turbidites and slumping may be linked to local faulting and subsequent earth movements.

The possibility of faults and the raising or lowering of local fault blocks requires that a good stratigraphic correlation be made across the Navidad area (Macellari, pers. comm.). The conformation or rejection of the bathymetric trends that seem apparent in the translation of the fossil assemblages relies on this stratigraphic correlation.

Summary

1. Three bathymetric zones are described, Zone I, Zone II, and Zone III. They are based on the molluscan genera that exhibit a relatively narrow bathymetric preference.
2. The Southern and Northern assemblages are separated based on the degree of Zone I, Zone II and Zone III faunal intermixing.
3. The Northern assemblage is a mix of Zone I and Zone II mollusks.
4. The Southern assemblage is a mix of Zone I, Zone II, and Zone III mollusks.
5. The transported material is in excellent condition and well mixed.
6. The mixing pattern reflects an increase in bathymetry from north to south from locations 329 through 332 and from east to west from locations 273 and 280.
7. The marine climate is subtropical to tropical.
8. An actively interacting molluscan community existed. This suggests relative environmental stability as well as an open marine environment being prominent.
9. Zone I has a rocky, sandy substrate mix, with possible localized mudflats.
10. Zone II is made up of fine to medium-grained sand substrate surrounding possible islands.
11. Zone III is made up of fine-grained sands and silts.

12. Irregularities within the Northern and Southern assemblages suggest an irregular bottom topography. Possibly in the form of islands in the Zone II.
13. The source area of the Zone I and Zone II genera in the Southern assemblage is to the north and to the east of Navidad.
14. Some of the sediments containing the fossil material is indicative of Turbidites.
15. The southward and westward thinning trends of the sedimentary beds documented by Cecioni (1978) place the sediment source areas to the north and to the east.
16. A north-south, flow oriented pocket of Turritella sp. gastropods is consistent with other sedimentary and bathymetric trends.
17. Evidence for turbidites decreases inland, to the east.
18. The presence of tuffaceous sandstones and brecciated pumice overlying the interlayered, fine-grained sandstones and turbidites, are proof of volcanic activity and suggest possible faulting in the area.
19. Seismic activity and faulting may have caused the slumps and turbidity currents.
20. The possibility of faults makes a good stratigraphic correlation essential to the reliability of the trends presented.

Conclusion

The bathymetric and sedimentary trends all point to Navidad as marking the position of a narrow, generally west-east trending marine shelf turning south, east of Navidad. The faunal composition is one of a stable, open marine environment. The environment is made up of intertidal, offshore shelf and offshore island (possibly just an irregular bottom topography), and deep-water zones.

Stratigraphic correlation across the area is essential if any firm conclusions are to be drawn from the trends presented here or elsewhere. Whether or not the trends that delineate the Miocene shoreline and marine community represents an embayment or just an irregular indentation along the west coast of Chile cannot be specifically addressed in this report.

Appendix 1

Latitude and Longitude

of the Sample Locations

Location (coastal)	South Latitude	West Longitude
332	33^{o} 52.67'	71^{o} 49.26'
331	33^{o} 52.67'	71^{o} 49.36'
339	33^{o} 52.84'	71^{o} 49.33'
285	33^{o} 53.09'	71^{o} 49.36'
326	33^{o} 53.09'	71^{o} 49.39'
327	33^{o} 53.19'	71^{o} 49.41'
328	33^{o} 53.30'	71^{o} 49.46'
329	33^{o} 53.53	71^{o} 49.46'
340	33^{o} 54.00'	71^{o} 50.00'
302	33^{o} 54.08'	71^{o} 50.15'
255	33^{o} 54.08'	71^{o} 50.15'
333	33^{o} 54.64'	71^{o} 50.57'
334	33^{o} 54.68'	71^{o} 50.56'
335	33^{o} 54.86'	71^{o} 50.72'
336	33^{o} 54.86'	71^{o} 50.62'
337	33^{o} 54.93'	71^{o} 50.72'
338	33^{o} 55.05'	71^{o} 50.82'
272	33^{o} 56.46'	71^{o} 51.18'
254	33^{o} 57.38'	71^{o} 52.33'

Location (Inland)	South Latitude	West Longitude
273	33^{o} 56.00'	71^{o} 46.82'
280	33^{o} 56.90'	71^{o} 48.16'

Appendix 2

List of Location Genera

254	272	338	337
Epitonium	Epitonium	Mytilus	Mytilus
Mytilus	Mya	Miltha	Terebra
Trochita	Neverita	Trochus	Turritella
Arca	Ostrea	---	---
Crepidula	Terebra		Penion
Lucina	Cancellaria		
Neverita	Cassis		
Oliva	Metulla?		
Solenosteira	Acteon		
Terebra	Bulla		
Cancellaria	Dentalium		
Glycymeris	Distorsio		
Acteon	Tellina		
Bulla	Turricula		
Calliostoma	Turritella		
Dentalium	Drepanocheilus		
Margarites	Limopsis		
Solariella	Microglyphis		
Turricula	Neilo		
Turritella	Voluta		
Miltha	Yoldiella		
Neilo	---		
Voluta	Penion		
Conus			
Natica			
Polinices			
Vermetus			
Cominella			
(Fusus)			
Gibbula			
Monoceros			
Olivancillaria			
Penion			
Sigaretus			
Struthiolarella			
Cucullaea			
(Fusinus)			
"Eulima"			

336	335	334	333
Oliva	Mytilus	Kelletia	Mytilus
Ficus	Neverita	Turbo	Diodora
Acteon	Oliva	Cassis	Ostrea
Bulla	Turricula	Dentalium	Oliva
Distorsio	Voluta	Distorsio	Solenosteira
Turritella	---	Pecten	Terebra
---	Monoceros	Trophon	Cancellaria
Penion	Ranella	Turricula	Cassis
	(Fusus)	Trochus	Glycymeris
		Voluta	Bulla
		---	Calliostoma
		Monoceros	Clavus
		Penion	Dentalium
		Sigaretus	Pecten
			Turricula
			Turritella
			Miltha
			Trochus
			Natica
			Polinices

			Monoceros

255	302	340	329
Epitonium	Dentalium	Oliva	Neverita
Neverita	Nucula	Glycymeris	Ficus
Oliva	Turricula	Drepanocheilus	Dentalium
Terebra	Turritella	Trochus	Natica
Cancellaria	---	Voluta	Polinices
Glycymeris		Xenophora	---
Calliostoma		---	Sigaretus
Clavus			
Dentalium			
Distorsio			
Turricula			
Voluta			
Natica			
Polinices			

Olivancillaria			
Penion			
Sigaretus			

328

Neverita
Ostrea
Oliva
Cassis
Bulla
Dentalium
Pecten
Trochus
Amiantis
Natica
Polinices

Olivancillaria
Sigaretus

327

Neverita
Cardium
Natica
Polinices

Monoceros
Olivancillaria
Ranella

326

Oliva
Solenosteira
Cassis
Ficus
Trochus

Austrosassia
Monoceros
Olivancillaria
Penion
Ranella

285

Oliva
Terebra
Cardium
Cassis
Distorsio
Turricula
Turritella
Natica

Monoceros
Olivancillaria
Penion

339

Terebra
Cancellaria
Distorsio
Polinices

Monoceros
Olivancillaria
Penion
(Fusus)

331

Mytilus
Neverita
Oliva
Cassis
Bulla
Dentalium
Turritella
Polinices

Austrosassia
Monoceros
Penion
Ranella

332

Ostrea
Oliva
Terebra
Cassis
Clavus
Dentalium
Distorsio
Natica

Monoceros
Penion
(Fusus)

280

Oliva

Raeta

273

Cancellaria
Distorsio
Amiantis
Polinices

Appendix 3

These genera exhibit a greater bathymetric variability than is resolvable into the set bathymetric zones. They are:

<u>Offshore to Deep</u>

1. Crepidula sp.
2. "Eulima" seminosa Gabbi
3. Metula? sp.
4. Pecten sp.
5. Solenosteira sp.
6. Tellina sp.
7. Trochus laevis Sowerby
8. Trophon sp.
9. Turbo sp.
10. Turritella sp.

<u>Intertidal to Deep</u>

1. Epitonium rugulosa Sowerby
2. Epitonium gabbi Philippi
3. Natica sp.
4. Polinices famula (Philippi)
5. Polinices sp.

1. Austrosassia bicegoi
2. Cominella obesis Phillipi
3. Cacullaea chilensis Philippi
4. (Fusinus) polypleuris Philippi
5. (Fusus) oncodes Philippi
6. (Fusus) pyruliformis Sowerby
7. (Fusus) Remondi (Philippi)
8. (Fusus) Striato-nodosus Hupe
9. (Fusus) turbenelloides Philippi

Appendix 4
The Feeding Preference

	Carnivore	other
1. Amiantis		•
2. Eulla	•	
3. Cardium		•
4. Cassis	•	
5. Conus	•	
6. Cypraea		
7. Diodora		•
8. Kelletia		
9. Margarites		•
10. Mya		•
11. Mytilus		•
12. Oliva	•	
13. Ostrea		•
14. Trochita		
1. Arca		x
2. Calliostoma		x
3. Cancellaria	x	
4. Clavus	x	
5. Dentalium		x
6. Distorsio		
7. Ficus	x	
8. Glycymeris		
9. Lucina		x
10. Neverita		x
11. Raeta	x	
12. Tellina		x
13. Terebra	x	
14. Vermetus		x
1. Acteon		
2. Drepanocheilus		
3. Limopsis		*
4. Voluta		
5. Microglyphis		
6. Miltha		*
7. Neilo		*
8. Nucula		*
9. Solariella		
10. Turricula	*	
11. Xenophora		
12. Yoldiella		*
Epitonium	–	
Crepidula		–
Solenosteira	–	
Metula?	–	
Pecten		–
Turritella		–
Natica	–	
Polinices	–	
Monoceros	–	
Olivancillaris	–	

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